REA

OUTLINE OF TYPES OF MOTORS AND THE MACHINES

WHICH THEY DRIVE

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I. Introduction

One of the most practical uses of electricity on the farm is to furnish power through the use of properly selected electric motors. As the electric motor is very different from other forms of power, a study of its operating characteristics, and uses should be of value to all who use electricity.

II. Comparison of electric and gasoline motors:

A. Efficiency - electric motor - 65 to 85%; gas engines seldom exceed 25% efficiency depending upon their size and type.

B. Life - electric motor - 15 to 25 or more years; gas engine, 10 to 15 years, seldom longer.

C. Maintenance - electric motor - none or very little; gas engine, usually high.

D. Ability to carry an overload - electric motor will handle 200% or greater overloads for very short periods; gas engine will take very small overload, generally less than 15%.

E. Safety - electric motor properly installed is no hazard to safety. If operating in dusty or hazardous locations, explosion proof motors may be purchased; gas engines burn very flamible fuel and back firing or after firing may start fires, indoor use dangerous to life and property.

F. Convenience - Electric motors start equally well in hot or cold weather and may easily be automatically operated; gas engines sometimes difficult to start and are not designed for automatic uses.

G. Installation - Electric motor quickly adapted to permanent or temporary installation. Motor can be closely connected to driven machine using short "V" belts for decreased cost and increased efficiency. Motors are easily reversed. Gas engine limited in its adaptation because of size, reversing direction of drive requires crossed belt, lining up long belt difficult. Generally, use flat belts with resultant slippage or excessive bearing wear from tight belts.

III. Load characteristics of Electric Motors

A. Three types of power requirements

1. Starting requirements
2. Acceleration or pull-up to speed requirements
3. Full load requirements

B. Above load requirements should be carefully considered when buying an electric motor. These requirements are usually expressed by engineers and motor manufacturers in terms of "torque."

C. Torque - an expression meaning turning power, the measure of a force tending to produce rotation.

1. Static torque

a. Starting torque
b. determined by locking the roter of the motor by means of a brake and measuring the force a given distance from the center of the shaft.
c. in certain types of electric motors starting torque may be as high as five times the running torque.

2. Pull-up torque
That force required to bring motor and machine up to rated speed. Amount dependent upon nature of load, machine friction, and the inertia of the driven machine.

3. Running torque
Rated or full load torque

4. Break-down torque
The maximum load that will stall the motor after it reaches full speed.

IV. Description of Motor Types

A. Split Phase Start Induction Run Motor - commonly called split phase motor.

1. Torque characteristics

a. Low starting torque - 230% rated torque
b. High starting current - 32 amps. max. on 1/4 h.p. size
c. Normal break-down torque 230%

2. *Speed - constant speed generally 1750 r.p.m.

3. Type machine used - suitable for very light loads which are easy to start.

   Examples: - fans, churns, washing machines, slow-speed grinders, drill presses, and other light, easy-starting machines.

4. Size

   a. Not usually made in sizes larger than 1/2 h.p. or smaller than 1/60 h.p.
   b. 1/4 and 1/3 h.p. are most common sizes and sell for about $15.00 for 115 volt, single phase current.

B. Capacitor-start, induction-run motor. (Usually distinguished from others by metal cylinder containing capacitor fastened to frame of motor.)

1. Torque Characteristics

   a. Static torque 435% rated torque
   b. Low starting current - 19.0 amps. max. for 1/4 h.p. motor.
   c. Break-down torque 265% rated load torque

2. Machine used on

   a. Used on machines which start frequently and require fairly high starting torques.
   b. Examples: water pumps, refrigerators, furnace stokers, oil burners and similar equipment.

3. Size

   a. Available in all standard sizes from 1/6 to 1 h.p. Larger capacities may be had on special order.

4. *Speed - constant speedmotor, generally 1750 r.p.m.

C. Repulsion start induction run motor.

1. Description

   a. Actually two motors in one. The electrical principle of the repulsion motor offers most efficient starting torque.
   b. The electrical principle of the induction motor offers the most efficient motor while running.
   c. Brush lifting and brush riding types.

      (1) Brush riding types are usually in smaller sizes, noisier, and brushes wear out quicker.
      (2) Either type is suited for rural use.

2. Torque Characteristics

   a. High starting torque - 550% rated load torque
   b. Low starting current, 13 amps. maximum for 1/4 h.p. motor
   c. Breakdown torque, 265% rated load torque

3. Machines on which used

   a. Used on machines that are hard to start and which have varying loads.
   b. Examples: cream separator, wood saw, hay chopper, ensilage cutter, feed grinder, hay hoist, grain elevator, and other applications about the farm.
   c. Torque characteristics and a low starting current make this a desirable motor type for general farm use.

4. Sizes

   a. Available in all size ranges.

5. *Speed - constant generally 1750 v.p.m.

D. Universal motors

1. Use either alternating or direct current

2. Speed may be varied by resistor in series with motor circuit. Depends upon load to hold speed down.

3. Sizes 1/150 h.p. to 1 h.p. Has exceptionally high starting torque.

4. Used on vacuum cleaners, sewing machines, floor polishers, food mixers and other household appliances.

*Speed of motors varies with design. Many other speeds available.

V. Protective Equipment

A. Purpose

Electric motors manually or automatically operated are frequently overloaded, therefore protective equipment is necessary to keep the motor from overworking under following conditions.

1. Inability of operator to tell when motor is being overloaded.

2. Jamming of motor drive or machine mechanism.

3. Inability to start or run due to low voltage. Motor draws excessive amperage when prevented from starting.

4. Failure of ventilation (inside motor).

B. Types of Protective Equipment

1. Built-in motor protection

   a. Usually a bi-metal element consisting of two metals bonded together that are affected differently by heat. This element is built in motor bracket near the winding which is in region of greatest heat. Dangerous or excess heat causes the element to bend, thus breaking the circuit.
   b. Manual type preferred for automatic feed grinders, farm shop tools and similar uses. Built-in motor protection may reset entirely automatically or manually.
   c. Built-in protective devices are not used in motors larger than two horsepower.

2. Protective devices part of motor control.

   Usually a bi-metal element is activated by a heating element in series with motor windings. Should the motor use extra current the element will heat and the bi-metal element will operate switch.

3. Fuses

   a. Fuse protecting circuit does not offer protection to motor as such a fuse must be large enough to allow motor to start.
   b. Overcurrent protection may be provided by using a small capacity fuse but cutting the fuse out of circuit when starting. Desirable only if motor is operating under a fixed load.
   c. Delay-type plug fustats which allow overloads for short periods may be used to protect both motor and circuit.

4. Circuit Breakers

   a. Allow more time before breaking the circuit on overloads.
   b. No fuses to be replaced.
   c. Re-establishing circuit accomplished by resetting the trip lever on the breaker.
   d. May be used as a switch.

VI. Starting Equipment

A. Motors require far more current at the instant of starting than to build up speed or to run. This surge of current in large motors may cause lights to flicker. Also, the high resultant torque may twist shaft or shear pins in the driven machines. Current-limiting starting equipment is usually required on motors of 5 h.p. and larger. Starting devices usually include protective equipment for motor. A low voltage drop-out also may be included. This device makes it necessary to manually restart the motor if for some reason the current source should fail.

B. Manual Starters

Reversing and non-reversing. These switches generally mounted on the wall or on the motor frame.

C. Magnetic Starters

Reversing and non-reversing. May be operated from a remote control station.

VII. Care and Maintenance of Electric Motors

A. Importance

If an electric motor is to furnish the reliable and efficient power of which it is capable, proper care and maintenance are necessary.

B. Insulation

1. The insulation has the shortest life of any material used in motors.

2. Heat is a major factor in insulation failure. As dust and dirt in windings prevent proper ventilation, the motors should be cleaned occasionally with air hose or vacuum cleaner.

3. As oil is injurious to insulation, it is important to prevent over-oiling bearings.

4. It is very important to keep the insulation dry. Should the motor be operated around milk houses or exposed places a splash-proof motor should be used.

C. Bearings

1. Oil bearings periodically.

2. Bearings are designed for a definite load. A belt too tight will cause abnormal bearing wear and undue heating. Belt should be just tight enough to prevent slipping.

2. Tension of belt should be released when not in use.

3. Misalignment of driven machine will cause undue bearing wear.

D. Brushes

1. If brushes spark, commutators or brushes may be worn or dirty. Clean by gently pressing 2/0 sandpaper, attached to a stick, against commutator while motor is running. Never use Emery Cloth.

2. When replacing worn down brushes they should be fitted by wrapping commutator with fine 2/0 sandpaper and revolving rotor by hand in the desired direction until a close fit is obtained.

3. If commutator is worn in ridges or out of round, have armature removed and commutator turned down on a lathe by an experienced repair man.

VIII. Pulleys and V-belt Drives

A. Most machines driven by electric motors are connected to the motor by V-belts and pulleys.

1. Machine designated as high speed if main shaft turns faster than 350 r.p.m. and slow speed if less.

2. Standard electric motors have speeds of 1140, 1720, 1750, 1800, 3520 or 3600 r.p.m. Most new motors have speed of 1725 to 1800 r.p.m.

B. Methods of obtaining the correct speeds of driven machines.

1. Change the pulley rates between the motor and the given machine.
Formula for computing the size of pulley:
Motor RPM x Motor pulley diameter equals r.p.m. of driven machine shaft x pulley diameter.

2. Use of jack shaft or similar means when the pulley size of the dirven machine is too large to be practical. "V" pulleys larger than 12 inches in diameter are quite expensive and the use of a jack shaft will generally keep all pulleys needed below this size.

a. On fractional horsepower motors a pulley as small as $1\frac{1}{2}$ inches may be used, and a pulley of any convenient larger size may be used on a jack shaft.

b. The speed of the jack shaft may be determined by using formula in "B" above. Size pulleys for driven machine may be determined by applying above formula a second time.

C. V-Belts

1. Flat belts slip badly on small diameter pulleys. Therefore V-belts are desirable when using electric motors.

2. Sizes - the following are standard width size of V-belts:

   a. Fractional h.p. - used on small motors. Belts are numbered 0, 1, & 2.
   b. "A" - used on fractional horsepower motors from 1/4 to 1 h.p.
   c. "B" - used on motors from 1 to 3 h.p. On motors up to $7\frac{1}{2}$ h.p. two or more "B" V-belts are used a multi-belt drive.
   d. "C", "D" and "E" size belts are used on large industrial motors.
   e. Multi-belt drives consist of two or more belts of sufficient total capacity to handle the load.

3. Belts may be purchased in any length by variations of 1 inch.

4. Length of belt should be very closely measured for permanently mounted motors and machines.

5. Belts should be matched for length on multi-belt drives.

6. Rockwood drive is name given to method of mounting an electric motor in such a way that the weight of motor keeps the belts tight. Exact belt length not necessary when Rockwood drive is used.

Attachment

AVERAGE STARTING CURRENT AND OVERLOAD PERCENTAGE

Compared with Rated Load Torque

	Fractional Horsepower Motors		
	Repulsion Start Induction Run	Capacitor Start Induction Run	Split Phase Induction Run
Static Torque	550%	435%	230%
Pull-up Torque	225%	250%	200%
Breakdown Torque	265%	265%	230%
Efficiency	66%	65%	65%
Maximum Starting current	13 amps.	19 amps.	32.0 amps.
	Integral Horsepower Motors		
Static Torque	400- 450%	250%	
Pull-up Torque	200%	200%	
Breakdown Torque	235%	210%	
Efficiency	81%	78%	
Maximum Starting Current	100 amps.	120 amps.	

Note: Above is for 5 h.p., 4 pole, 220 volt, 60 cycle motor. S Smaller motors are somewhat less efficient, and large motors more efficient than here indicated. Maximum starting current varies directly with size of motor.

Operating characteristics on torque, starting currents and overload percentages taken from Century Electric Company literature.